HWG | HARRIS, WILTSHIRE & GRANNIS LLP

December 1, 2016

Ex Parte

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band, ET Docket No. 13-49

Dear Ms. Dortch,

On November 29, 2016, Danielle Piñeres of NCTA – The Internet & Television Association, Bruce Kostreski, a consultant for NCTA, John Kuzin of Qualcomm, and I, met with Julius Knapp, Jamison Prime, Geraldine Matise, and Ira Keltz, all of the Office of Engineering and Technology (OET). Reza Biazaran, Steve Jones, and Dusmantha Tennakoon, all of OET; V.K. Jones and Tevfik Yucek of Qualcomm; Chris Szymanski and Vinko Erceg of Broadcom; and Rob Alderfer and Joey Padden of CableLabs participated by phone. In the meeting, we discussed OET's testing of spectrum sharing proposals for the 5.9 GHz band, consistent with the attached presentation. We also discussed the characteristics of Dedicated Short Range Communications (DSRC) as set out in a Department of Transportation document that was contributed to USWP5A and became the U.S. contribution to the recent ITU-R WP5A meeting. That document is also attached here.

Pursuant to the FCC's rules, I have filed a copy of this notice electronically in the above-referenced proceeding. If you require any additional information, please contact the undersigned.

Sincerely,

Paul Margie
Counsel for NCTA – The Internet & Television Association

cc: Julius Knapp, Jamison Prime, Geraldine Matise, Ira Keltz, Reza Biazaran, Steve Jones, and Dusmantha Tennakoon

5.9 GHz Band Testing

Ensuring effective testing of the rechannelization proposal

Agenda

- Testing the rechannelization proposal
- Sharing in the lower 45 MHz
- Observation and publication of results

Testing the rechannelization proposal

- Qualcomm and Broadcom propose that the FCC designate the upper 30 MHz of the 5.9 GHz band exclusively for latency-sensitive DSRC signals, and allow Wi-Fi sharing with less latency-sensitive DSRC signals in the lower part of the band
- OET's test plan recognizes that to test the core of this proposal (protecting latency-sensitive traffic by granting it exclusivity in the upper 30 MHz), the test should examine out of band emissions from Wi-Fi devices operating in the lower 45 MHz of U-NII-4 into the top 30 MHz of the band

Testing the rechannelization proposal

- Rechannelization would not consolidate 7 channels of DSRC traffic into 3 channels
  - It would move latency-sensitive BSM safety operations from channel 172 to a higher channel and designate two additional channels for other latency-sensitive DSRC operations
  - Less latency-sensitive traffic planned for the lower 45 MHz could remain in place
  - Rechannelization therefore would not increase DSRC self-interference into the BSM channel due to higher volumes of traffic on adjacent DSRC channels
- Rechannelization would provide more spectral separation from adjacent-channel U-NII-3 operations than BSM traffic receives today
  - Channel 172 has 5 MHz of separation from U-NII-3
  - If BSM traffic occupies channel 182 or 184, it will have greater *(*10 or 20 MHz) separation from U-NII-4 traffic and can benefit from appropriate operational requirements

Testing the rechannelization proposal

- Interference to DSRC from other licensed users
  - Despite claims that DSRC is exceptionally vulnerable to interference, DSRC proponents have not revealed any interference testing relating to co-channel federal radar or adjacent C-Band or fixed operations – and DSRC radios do not appear to have any mechanism for protecting even basic safety messages from these potential interferers
  - Rechannelization would not exacerbate interference from these licensed users
    - Federal radar operations "are primarily military systems that can tune across the entire 5400-5900 MHz frequency range,"[1] therefore interference to DSRC from federal radar is likely to be less in the 5895-5925 MHz band if radars do not operate above 5900
    - There has been no suggestion that adjacent satellite or fixed operations are likely to interfere with immediately adjacent DSRC Channel 184, so it is unclear how moving channel 172 to the upper 30 MHz could exacerbate interference from these licensed users

[1] NTIA, *Evaluation of the 5350-5470 MHz and 5850-5925 MHz Bands Pursuant to Section 6406(b) of the Middle Class Tax Relief and Job Creation Act of 2012* , at 5-2 *(Jan. 2013)* .

Sharing in the lower 45 MHz

- NCTA has proposed that the FCC should not grant non-safety DSRC communications—which do not require the same low latency as BSMs—special status in the lower 45 MHz
- The FCC need not grant preferential interference rights to DSRC entertainment, payment, mapping, and other non-latency-sensitive applications
- *As a result, the FCC need not test devices' ability to protect non-latency-sensitive DSRC communications in the lower 45 MHz to assess the rechannelization proposal*

Sharing in the lower 45 MHz

The test plan states that OET will test the capability of rechannelization devices to share in the lower 45 MHz

Two possibilities include:

1. 802.11 carrier-sense (CSMA/CA) employing clear channel access (CCA)
2. Prioritization through Enhanced Distributed Channel Access (EDCA)

Sharing in the lower 45 MHz

To properly test either CCA or EDCA sharing, the FCC should test aligned 20 MHz DSRC channels

- Qualcomm and Broadcom have not proposed that CCA or EDCA be used to share with 10 MHz DSRC transmissions or with non-aligned 20 MHz DSRC channels—and did not design their devices for this purpose
- Testing devices on 10 MHz DSRC channels or non-aligned channels would therefore not adequately test their proposals, and would likely lead to incomplete and false conclusions

Sharing in the lower 45 MHz

To properly test EDCA prioritization, the FCC should:

- Test DSRC devices that operate in 20 MHz channelization (using 20 MHz signal bandwidth) in Channels 173 & 177, and transmit packets assigned to the appropriate access class
- Work with Wi-Fi prototype equipment providers to allow any software changes necessary to react to testing and allow full implementation
- In the alternative, OET could test proof of concept for EDCA prioritization by using traffic generation software (e.g., iPerf) to simulate interactions between particular DSRC and Wi-Fi traffic access classes, for example:
  - DSRC uses AC_VO/AC3 traffic
  - Wi-Fi uses background-class traffic

Observation and publication of results

- We would welcome an opportunity to observe testing at a time convenient for lab staff, as suggested during the lab open house
- Publication of test results after each phase of testing—or more often, if feasible—would foster more productive dialogue between the relevant agencies and stakeholders and improve the quality of test results

Radiocommunication Study Groups

INTERNATIONAL TELECOMMUNICATION UNION

Received: 28 October 2016

Reference: Doc. 5A/114 (Annex 29); WRC-19 AI 1.12

Document 5A/216-E
31 October 2016
English only

United States of America

PROPOSED TEXT FOR SUBSECTION 7.5: APPLICATIONS, IN SECTION 7: ADVANCED ITS RADIOCOMMUNICATION, OF THE WORKING DOCUMENT TOWARD A PRELIMINARY DRAFT NEW REPORT ITU-R M.[ITS USAGE]

Introduction

Working Party 5A is the group responsible for Question ITU-R 205-5/5 Intelligent transport systems. As such, WP 5A has developed a workplan, and, as part of that workplan, has initiated development of a working document toward a preliminary draft new Report ITU-R M.[ITS USAGE] to address "Intelligent transport systems (ITS) usage in ITU Member States".

Discussion

Annex 29 to Document 5A/114: Working Party 5A Chairman's Report working document toward a preliminary draft new Report ITU-R M.[ITS USAGE]; Intelligent transport systems (ITS) usage in ITU Member States; (Question ITU-R 205-5/5), provides a framework to document ITS usage in ITU Member States. The United States has been actively involved in Wireless Access in Vehicular Environments (WAVE) research, development and deployment for many years and has extensive knowledge and understanding of the requirements of applications that contribute to safety, transportation system efficiencies, mobility and environmental stewardship in the context of ITS. The United States has developed technical requirements for WAVE to support these application requirements.

Proposal

The proposed text to be added to subsection 7.2: Technical characteristics, in section 7: Advanced ITS radio communication, of the working document toward PDNRep ITU-R M.[ITS USAGE]; in Doc. 5A/114 (Annex 29) and the proposed text to be added to subsection 7.5: Applications, in section 7: Advanced ITS radio communication, of the working document toward PDNRep ITU-R M.[ITS USAGE]; in Doc. 5A/114 (Annex 29) are provided in the Annex.

Annex: 1

ANNEX

Source: Document 5A/114 (Annex 29)

WORKING DOCUMENT TOWARD A PRELIMINARY
DRAFT NEW REPORT ITU-R M.[ITS USAGE]

Intelligent transport systems (ITS) usage in ITU Member States

(Question ITU-R 205-5/5)

TABLE OF CONTENTS

...

[Editor's note: All the texts may be addressed in future contributions to this document.]

[Editor's note: Renumbering is required for the figures and tables.]

1 Scope

...

2 Background

...

3 Related documents

...

4 List of acronyms and abbreviations

...

5 Overview of ITS radio communication and vehicular radar

...

6 [Legacy] ITS radio communication

...

7 Advanced ITS radio communication

7.1 Overview

...

7.2 Technical characteristics

...

7.2.1 Wireless Access in Vehicular Environments (WAVE)

WAVE is a dedicated mobile radiocommunication system for providing non-voice communications among vehicles that travel on roads, rails, or other dedicated facilities; as well as between those vehicles and the transportation infrastructure. WAVE is therefore a fundamental technology for ITS communications, helping link roads, traffic and vehicles covered by ITS deployment with coordinated, interoperable information technology. This particular wireless technology could be transformational to the evolution of transportation systems, since it provides very localized, low latency communications capabilities on a peer-to-peer basis. These capabilities are intended to support the planned, as well as the still unforeseen, data needs of the evolving, more automated, future transportation system. WAVE systems specifically utilize the broadcast mode of operations as the primary means to support public benefits; and also communicate using two-way communications between vehicles and infrastructure, including the ability to provide lower priority messages related to the specific units involved in a variety of public and private transportation environments.

7.2.2 Technical and Operational Characteristics

On-board equipment (OBE): The OBE consists of communications and processing equipment installed in vehicles to enable WAVE communications with other vehicles and infrastructure, and support WAVE-enabled applications. OBEs may be most effective when integrated into the vehicle and able to interface with other on-board equipment such as the vehicle's sensor suite, anti-lock braking system, and other subsystems, allowing it to complement these existing systems.

Roadside unit (WAVE RSU): A WAVE RSU is installed above or alongside the road or other infrastructure and communicates with passing OBEs by the use of radio signals. An RSU consists of radio communication circuits, an application processing circuit and related equipment. It usually has data linkages to traffic management centers (TMCs) and to other roadside equipment (such as traffic signal controllers), as well as to the Internet to exchange data and to maintain security credential information.

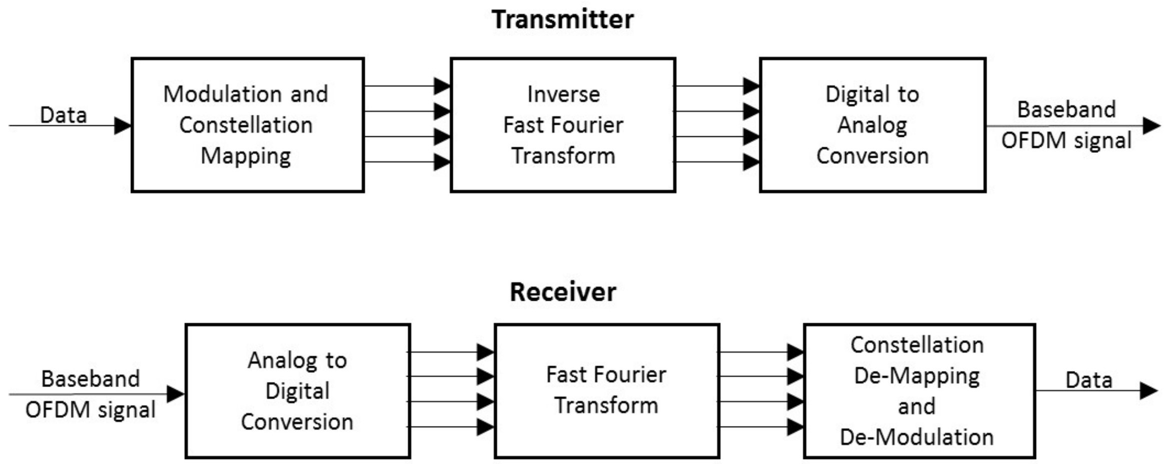
The WAVE systems operate by transmitting radio signals for the exchange of data among vehicle-mounted OBEs, and between OBEs and infrastructure-based RSUs. By adhering to requirements set by industry standards, these systems accomplish a data exchange that ensures that data is interoperable across a wide range of device and application manufacturers. Interoperability is key to support the rapid, standardized adoption of applications that deliver critical safety-related, system and operational efficiencies, and other public benefits.

Much of the information to complete the following tables comes from Std 802.11-2012[1].

The modulation used for WAVE is 'half-clocked' OFDM on 10 MHz channels. Below are basic OFDM transmitter and receiver block diagrams:

[1] IEEE Std 802.11TM-2012, IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

Transmitter and Receiver[2]



Adjacent and Next-Adjacent Channel Rejection Receiver Characteristics[3]

Modulation	Coding Rate	Receiver Performance (dB)		Optional Enhanced Receiver Performance (dB)	
		Adjacent Channel Rejection	Next Adjacent Channel Rejection	Adjacent Channel Rejection	Next Adjacent Channel Rejection
BPSK	1/2	16	32	28	42
BPSK	3/4	15	31	27	41
QPSK	1/2	13	29	25	39
QPSK	3/4	11	27	23	37
16-QAM	1/2	8	24	20	34
16-QAM	3/4	4	20	16	30
64-QAM	2/3	0	16	12	26
64-QAM	3/4	-1	15	11	25

2 USDOT diagram based upon Std 802.11-2012 and generic OFDM principles.

3 Based upon information from IEEE Std 802.11™-2012, IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications; at 1612 - 1613.

Maximum STA transmit power classification for the 5.85–5.925 GHz band in the United States[4]

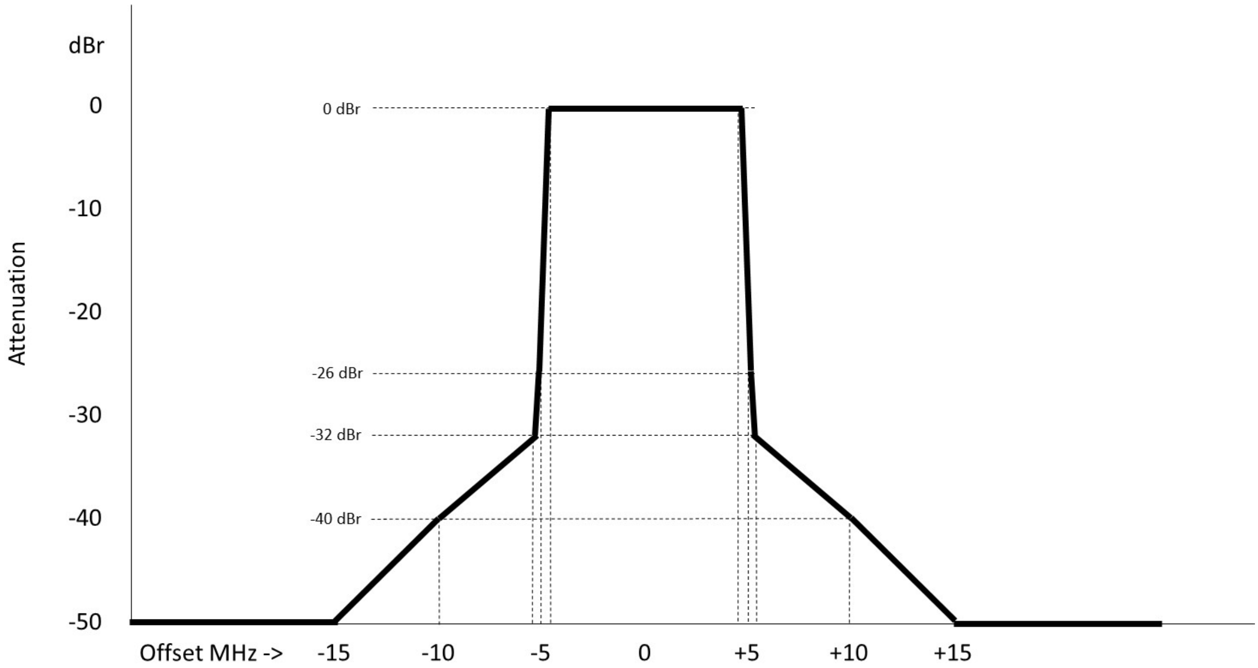
STA transmit power classification	Maximum STA transmit power (mW)	Maximum permitted EIRP (dBm)
A	1	23
B	10	33
C	100	33
D	760 Note that for this class higher power is permitted as long as the power level is reduced to this level at the antenna input and the emission mask specifications are met.	33 for nongovernment 44.8 for government

Spectrum mask data for 10 MHz channel spacing[4]

STA transmit power class	Permitted power spectral density, dBr				
	± 4.5 MHz offset (±f1)	**± 5.0 MHz offset (±f2)**	**± 5.5 MHz offset (±f3)**	**± 10 MHz offset (±f4)**	**± 15 MHz offset (±f5)**
Class A	0	–10	–20	–28	–40
Class B	0	–16	–20	–28	–40
Class C	0	–26	–32	–40	–50
Class D	0	–35	–45	–55	–65

4 IEEE Std 802.11™-2012, IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications; Annex D.

Transmit spectrum mask for 10 MHz OBE transmission (Class C typical)[5]



WAVE is being pursued in the United States "to improve traveler safety, decrease traffic congestion, facilitate the reduction of air pollution, and help to conserve vital fossil fuels"[6], and as a particular focus in the United States, to reduce highway fatalities[7]. In order to address the need for advanced ITS to provide these public benefits, a number of applications have been developed, with more still under development, to leverage the unique short range characteristics of WAVE. These applications include communications among vehicles and other mobile end users, as well as between mobile users and roadside infrastructure.

WAVE applications may have access to each of the seven 10 MHz channels on a dynamic assignment basis under the direction of the control channel as shown in the following table, but do not use the 20 MHz combined channels, designated as Channels 175 and 181 in the table. This band plan provides dedicated channels for crash-imminent safety-related (Channel 172) and high-powered public safety-related (Channel 184) applications[8], as well as flexible assignment of other service channels through the control channel mechanism to support the wide range of advanced ITS WAVE applications. Many applications will only partially use a particular assignable channel at a particular time and location, permitting sharing among WAVE applications on individual assignable service channels.

Safety-related applications which are not pre-assigned to the dedicated channels typically use the control channel to transmit very short, infrequent messages, or else use WAVE Service Announcements (WSA) on the control channel to indicate a service channel upon which to

---

5 USDOT diagram based upon Std 802.11-2012.

6 FCC Report and Order, October 1999, ET Docket No. 98-95.

7 Press Release, U.S. Transportation Secretary Mineta Announces Opening of Crash-Preventing "Intelligent Intersection" Test Facility (June 24, 2003) (http://www.its.dot.gov/press/fhw2003.htm).

8 FCC 06-110; MEMORANDUM OPINION AND ORDER; July 2006; ET Docket No. 98-95.

communicate, if those messages are less dependent upon having very low latency. Lower priority messages typically use WSAs on the control channel to be assigned to a service channel which is not fully occupied by safety-related communications at that location at that time. This flexible designation of application messages to different service channels in various locations facilitates spectral efficiency and reduces interference among WAVE applications.

Band Plan for WAVE in the United States[9]

5.850 GHz							5.925 GHz
		CH175			CH181		
5 850-5 855 reserve 5 MHz	CH172 service 10 MHz	CH174 service 10 MHz	CH176 service 10 MHz	CH178 control 10 MHz	CH180 service 10 MHz	CH182 service 10 MHz	CH184 service 10 MHz

Note – This band plan may need to be revised if regulatory changes occur as a result of ongoing regulatory proceedings in the United States.

7.3 Frequency usage

...

7.4 Standardization

...

7.5 Applications

[Editor's note: Text to be added]

WAVE is being pursued in the United States "to improve traveler safety, decrease traffic congestion, facilitate the reduction of air pollution, and help to conserve vital fossil fuels"[6], and as a particular focus in the United States, to reduce highway fatalities[7]. Although not yet widely deployed, the United States has developed multiple applications, a number of which have been tested in large-scale field tests or operated in model deployments[10]. This progress has provided the United States with extensive knowledge of these applications that contribute to transportation safety, mobility and environmental stewardship in the context of advanced ITS. The WAVE ITS

[9] FCC 03-324 REPORT AND ORDER, December 2003, ET Docket No. 98-95.

[10] "Collaborative Connected Vehicle Research Update" (http://www.its.dot.gov/presentations/pdf/V2V_Collaborative_Research_MikeLukuc2013.pdf) at 10-12; "Safety Pilot Model Deployment: Lessons Learned and Recommendations for Future Connected Vehicle Activities" (http://ntl.bts.gov/lib/59000/59300/59361/FHWA-JPO-16-363.pdf) at 11-12; "CV Applications Already Deployed by Responding Agencies" (http://transops.s3.amazonaws.com/uploaded_files/V2I%20DC%20TWG%201%20-%20January%2028%2C%202016%20Webinar%20Slides%20V3.pptx) at 30; "Maricopa County Department of Transportation (MCDOT) SMARTDriveSM Program" (http://www.mcdot.maricopa.gov/business/connected-vehicles.aspx); "Connected Vehicle Pilot Deployment Program Phase 1: Concept of Operations (ConOps) - New York City" (http://ntl.bts.gov/lib/59000/59300/59360/FHWA-JPO-16-299.pdf) at 36; "Connected Vehicle Pilot Deployment Program: ICF/Wyoming Concept of Operations" (http://www.its.dot.gov/pilots/pdf/ICF_ConOpsWebinar_02042016.pdf) at 34

applications are designed to perform operations related to the improvement of traffic safety and traffic flow, as well as other intelligent transport service applications, including enhancing transportation systems efficiencies and operations (for example, facilitating roadway freight movements or transportation management during emergency responses). The main points of focus for the US deployment of advanced ITS applications using WAVE communications include: nationwide interoperability; long-term technical stability; voluntary industry standards; and support for public benefits.

The following application examples are taken from US Department of Transportation's Connected Vehicle Reference Implementation Architecture (CVRIA)[11], which also provides further definitions and reference implementation information. In general, the WAVE ITS applications in the United States may be grouped into general categories that apply to transportation operations on a day-to-day basis, although there are no strict boundaries between the categories and overlaps among categories are common. There is also a category for core services that are the foundation for data exchange, interoperability, security, and privacy. The following subsections provide application examples within a selection of these categories.

7.5.1 V2V Safety-Related Applications

These are applications with a primary focus of enhancing safety through vehicle-to-vehicle communications to address the prevention of imminent crashes, and/or mitigation of the injuries and damages that might result if a crash cannot be prevented. Since this category represents a major focus of the United States WAVE ITS development and deployment, there tend to be a large number of these applications, and they are typically in later stages of deployment than applications in the other categories.

This is not a complete listing of V2V safety-related applications in the United States, since others are also being deployed, and continuing innovation is expected.

7.5.1.1 Blind Spot Warning + Lane Change Warning[11]

This application has been operated in model deployments to warn the driver of the vehicle during a lane change attempt if the blind-spot zone into which the vehicle intends to switch is, or will soon be, occupied by another vehicle.

7.5.1.2 Control Loss Warning[11]

This application is being developed to enable a vehicle to broadcast a self-generated, control loss event to surrounding vehicles.

7.5.1.3 Do Not Pass Warning[11]

Has been operated in model deployments to warn the driver of the vehicle when a slower moving vehicle, ahead and in the same lane, cannot be safely passed.

7.5.1.4 Emergency Electronic Brake Light[11]

Has been operated in model deployments to enable a vehicle to broadcast a self-generated emergency brake event to surrounding vehicles.

[11] http://www.iteris.com/cvria/html/applications/applications.html.

7.5.1.5 Emergency Vehicle Alert[11]

Has been developed and is planned for operation in pilot deployment to alert the driver about the location of and the movement of public safety vehicles responding to an incident so the driver does not interfere with the emergency response.

7.5.1.6 Forward Collision Warning[11]

Has been operated in model deployments to warn the driver of the vehicle in case of an impending rear-end collision with another vehicle ahead in traffic.

7.5.1.7 Intersection Movement Assist[11]

Has been operated in model deployments to warn the driver of a vehicle when it is not safe to enter an intersection due to high collision probability with other vehicles at stop sign controlled and uncontrolled intersections.

7.5.1.8 Motorcycle Approaching Indication[11]

This application is intended to warn the driver of a vehicle that a motorcycle is approaching.

7.5.1.9 Situational Awareness[11]

Has been developed and is planned for installation and operation in pilot deployment to determine if the road conditions measured by other vehicles represent a potential safety hazard for the vehicle containing the application.

7.5.2 V2I Safety-Related Applications

The applications in this category are targeted toward enhancing roadway safety through vehicle-to/from-infrastructure communications. The following examples of the V2I safety applications provide a view of the diversity possible within this category. As in the safety category examples, the following is not a complete listing of such applications in the United States.

7.5.2.1 Curve Speed Warning[11]

Has been operated in model deployments to allow a connected vehicle to receive information that it is approaching a curve along with the recommended speed for the curve.

7.5.2.2 Emergency Vehicle Preemption[11]

Has been operated in model deployments to provide a very high level of priority for emergency first responder vehicles to facilitate safe and efficient movement through intersections.

7.5.2.3 Enhanced Maintenance Decision Support System[11]

Is being developed to incorporate the additional information that can come from collecting road weather data from connected vehicles into existing Maintenance Decision Support System (MDSS) capabilities to generate improved plans and recommendations to maintenance personnel.

7.5.2.4 Incident Scene Work Zone Alerts for Drivers and Workers[11]

Has been operated in model deployments to provide warnings and alerts relating to incident zone operations. One aspect of the application is an in-vehicle messaging system that provides drivers with merging and speed guidance around an incident. Another aspect is providing in-vehicle incident scene alerts to drivers and on-scene workers.

7.5.2.5 In-Vehicle Signage[11]

Has been operated in model deployments to augment regulatory, warning, and informational signs and signals by providing information directly to drivers through in-vehicle devices.

7.5.2.6 Oversize Vehicle Warning[11]

Has been developed to use external measurements taken by the roadside infrastructure, and transmitted to the vehicle, to support in-vehicle determination of whether an alert/warning is necessary.

7.5.2.7 Pedestrian in Signalized Crosswalk Warning[11]

Has been developed and is planned for operation in pilot deployment to provide to the connected vehicle information from the infrastructure that indicates the possible presence of pedestrians in a crosswalk at a signalized intersection.

7.5.2.8 Railroad Crossing Violation Warning[11]

Is being developed to alert and/or warn drivers who are approaching an at-grade railroad crossing if they are on a crash-imminent trajectory to collide with a crossing or approaching train.

7.5.2.9 Red Light Violation Warning[11]

Has been operated in field tests and is planned for operation in pilot deployment to enable a connected vehicle approaching an instrumented signalized intersection to receive information regarding the signal timing and geometry of the intersection.

7.5.2.10 Reduced Speed Zone Warning / Lane Closure[11]

Has been developed and is planned for operation in pilot deployment ~~Is being deployed~~ to provide connected vehicles which are approaching a reduced speed zone with information on the zone's posted speed limit and/or if the lane is closed or shifted.

7.5.2.11 Restricted Lane Warnings[11]

Are being developed to provide the connected vehicle with travel lane restrictions, such as if the lane is restricted to high occupancy vehicles, transit, or public safety vehicles, or has defined eco-lane criteria.

7.5.2.12 Roadside Lighting[11]

This application is being developed to use the presence of vehicles based on V2I communications as an input to control of roadside lighting systems.

7.5.2.13 Stop Sign Gap Assist[11]

Is being developed to improve safety at non-signalized intersections by helping drivers on a minor road stopped at an intersection understand the state of activities associated with that intersection by providing a warning of unsafe gaps on the major road.

7.5.2.14 Stop Sign Violation Warning[11]

Is being developed to improve safety at intersections with posted stop signs by providing warnings to the driver approaching an unsignalized intersection.

7.5.2.15 Transit Vehicle at Station/Stop Warnings[11]

Is being developed to inform nearby vehicles of the presence of a transit vehicle at a station or stop and to indicate the intention of the transit vehicle in terms of pulling into or out of a station/stop.

7.5.2.16 Vehicle Turning Right in Front of a Transit Vehicle[11]

Has been operated in model deployments to determine the movement of vehicles near to a transit vehicle stopped at a transit stop and provide an indication to the transit vehicle operator that a nearby vehicle is pulling in front of the transit vehicle to make a right turn.

7.5.3 Transportation System Efficiency and Operations Applications

These applications are designed to improve the flow of traffic and generally support the efficient operation of the transportation system. The following subsections provide selected examples of mobility applications.

7.5.3.1 Cooperative Adaptive Cruise Control[11]

Is being developed to provide an evolutionary advancement of conventional cruise control systems and adaptive cruise control (ACC) systems by utilizing V2V communication to automatically synchronize the movements of many vehicles within a platoon.

7.5.3.2 Intelligent Traffic Signal System[11]

Has been operated in model deployments to use both vehicle location and movement information from connected vehicles as well as infrastructure measurement of non-equipped vehicles to improve the operations of traffic signal control systems.

7.5.3.3 Intermittent Bus Lanes[11]

Is being developed to provide dedicated bus lanes during peak demand times to enhance transit operations mobility.

7.5.3.4 Pedestrian Mobility[11]

Has been developed and is planned for operation in pilot deployment to integrate traffic and pedestrian information from roadside or intersection detectors and new forms of data from wirelessly connected, pedestrian (or bicyclist) carried mobile devices (nomadic devices) to provide input to dynamic pedestrian signals or to inform pedestrians when to cross and how to remain aligned with the crosswalk based on real-time Signal Phase and Timing (SPaT) and MAP information.

7.5.3.5 Performance Monitoring and Planning[11]

Has been operated in model deployments to use information collected from connected vehicles to support operational functions, including performance monitoring, transportation planning, condition monitoring, safety analyses, and research.

7.5.3.6 Speed Harmonization[11]

Is being developed to determine speed recommendations based on traffic conditions and weather information. Recommendations can be regulatory (e.g. variable speed limits) or advisory in order to change traffic speed on links that approach areas of traffic congestion that affect flow.

7.5.3.7 Transit Signal Priority[11]

Has been operated in model deployments to use V2I communications to allow a transit vehicle to request a priority at one or a series of intersections.

7.5.3.8 Variable Speed Limits for Weather-Responsive Traffic Management[11]

Is being developed to provide real-time, location-specific information on appropriate speeds for current conditions and to warn drivers of imminent road conditions.

7.5.3.9 Vehicle Data for Traffic Operations[11]

Is being developed to use information obtained from vehicles in the network to support traffic operations, including incident detection and the implementation of localized operational strategies.

7.5.4 Environment Applications

The environment category includes applications that are designed to support environmental sustainability for the transportation system. From protecting the air quality within a sensitive zone, to ensuring the smallest environmental footprint for a connected vehicle to pass through an intersection, the example environment applications presented below illustrate the wide range of opportunities to use ITS technology to reduce the environmental impact of the transportation system.

7.5.4.1 Eco-Approach and Departure at Signalized Intersections[11]

Has been developed to use wireless data communications sent from a roadside equipment (RSU) unit to connected vehicles to encourage "green" approaches to and departures from signalized intersections.

7.5.4.2 Eco-Speed Harmonization[11]

Is being developed to determine eco-speed limits based on traffic conditions, weather information, greenhouse gas emissions, and criteria pollutant information.

7.5.4.3 Low Emissions Zone Management[11]

Is being developed to support the operation of a low emissions zone that is responsive to real-time traffic and environmental conditions. Low emissions zones are geographic areas that seek to restrict or deter access by specific categories of high-polluting vehicles into the area to improve the air quality within the geographic area.

7.5.5 Core Services

DSRC applications rely upon a set of core services that support the cooperative and interoperable nature of the independently-operated applications and technologies that communicate and share information as well as independently authenticate devices before accepting data.

7.5.5.1 Core Authorization[11]

Has been operated in model deployments to manage the authorization mechanisms to define roles, responsibilities and permissions for other connected vehicle applications. This allows system administrators to establish operational environments where different connected vehicle system users may have different capabilities. For instance, certain vehicle elements may be authorized to request signal priority, while those without those permissions would not.

7.5.5.2 Location and Time[11]

Is being developed to show the external systems and their interfaces to provide accurate location and time to connected vehicle devices and systems.

7.5.5.3 Security and Credentials Management[11]

Has been operated in model deployments to ensure trusted communications between mobile devices and other mobile devices or roadside devices and to protect data they handle from unauthorized access.

7.5.6 Non-Priority Communications[12], such as E-Commerce and Infotainment

ITS in the 5.9 GHz band might also have numerous commercial applications. Below are a few applications envisioned for ITS in this band.

7.5.6.1 Wireless Advertising[13]

The Wireless Advertising application would provide businesses and other entities located near a roadway the opportunity to deliver advertisements to the occupants of a passing vehicle. The application could restrict the recipients of these advertisements to only certain motorists to maximize the relevance of these advertisements to consumers.

7.5.6.2 Vehicle-to-Infrastructure Internet Connection[14]

ITS spectrum and technologies could be used to provide Internet access to occupants of a moving vehicle by transmitting data to a network of roadside units or, potentially, using a vehicle-to-vehicle mesh network.

---

[12] Other applications may also be non-priority communications depending on how they are deployed, the entity that deployed them, and other considerations. *See* 47 CFR, Section 90.377.

[13] *See, e.g.*, GM Global Technology Operations, Inc., *Using V2X In-Network Message Distribution and Processing protocols to Enable Geo-Service Advertisement Applications*, U.S. Patent Appl. No. 12/415,756 (filed 31 Mar. 2009), https://www.google.com/patents/US20100250346; Mitsubishi Denki Kabushiki Kaisha, *Vehicle-Roadside Service Providing System*, U.S. Patent No. 6,768,934 (issued 27 July 2004), http://www.google.com/patents/US6768934.

[14] *See, e.g.*, Comments of Oakland County Michigan at 5, ET Docket No. 13-49 (filed 5 July 2016).

7.5.6.3 Drive-Thru Payments[15]

The Drive-Thru Payments application would allow motorists to automatically pay for goods and services purchased from within the vehicle, such as at the "drive-thru" window of a restaurant.

7.5.6.4 Vehicle-to-Vehicle Messaging[16]

If an occupant notices any problem (e.g. flat tire, missing gas cap, open trunk, etc.), it can send a message to the corresponding vehicle. The message could be chosen from a list of pre-defined or customized messages.

7.5.7 Other Applications

The main intention of this category is to provide public benefits by supporting the safe and efficient operation of the overall transportation system. The other applications category may also include proprietary or commercial applications, but at a lower priority level.

7.5.7.1 Border Management Systems[11]

Have been developed to provide international border registration, pre-processing and border inspection capabilities.

7.5.7.2 Electric Charging Stations Management[11]

Is being developed to provide an exchange of information between vehicle and charging station to manage the charging operation.

7.5.7.3 Integrated Multi-Modal Electronic Payment[11]

Has been developed to use connected vehicle roadside and vehicle systems to provide the electronic payment capability for toll systems, parking systems, and other areas requiring electronic payments.

---

15 NAT'L HIGHWAY TRAFFIC & SAFETY ADMIN., Vehicle Safety Communications Project Task 3 Final Report—Identify Intelligent Vehicle Safety Applications Enabled by DSRC at 14 (Mar. 2005) ("NHTSA DSRC Applications Report"), https://www.nhtsa.gov/DOT/NHTSA/NRD/Multimedia/PDFs/Crash%20Avoidance/2005/CAMP3scr.pdf; Presentation by Jinhua Guo, Director of Vehicular Networking Systems Research Lab, University of Michigan-Dearborn, 2006 US Army VI Winter Workshop, *Vehicle Safety Communications in DSRC* at 25 (2006); see also Jinhua Guo and Nathan Balon, University of Michigan – Dearborn, *Vehicular Ad Hoc Networks and Dedicated Short-Range Communication* at 18 (26 June 2006), http://nathanbalon.net/projects/cis695/vanet_chapter.pdf; GM Global Technology Operations, LLC, *Vehicular Wireless Payment Authorization Method*, U.S. Patent Appl. No. 12/631,680 (filed 4 Dec. 2009), https://www.google.com/patents/US20110136429; Henry Bzeih, Kia Motors America, *Safety Applications in a Connected Vehicle* at 13, http://www.in-vehicle-infotainment-summit.com/media/downloads/42-day-2-henry-bzeih-kia-connected-car.pdf (last accessed 24 June 2016).

16 NHTSA DSRC Applications Report at 34.

7.5.7.4 Road Weather Information for Maintenance and Fleet Management Systems[11]

This application is being developed to be either a stand-alone application or as an adjunct to the Enhanced-MDSS. The data collected can be used by maintenance or fleet dispatchers to monitor the status of the maintenance operations, or the data can be used as an input to the Enhanced-MDSS application.

7.5.7.5 Smart Roadside Initiative[11]

Is being developed to improve the efficiency and safety of the Nation's roadways by providing for the exchange of important safety and operational information regarding commercial vehicles.

7.6 Region 1

...

7.7 Region 2

...

7.8 Region 3

...

8 Millimetre-wave vehicular and road radar

...

9 Conclusions

...

____